J Sci Food Agric 1992, **60**, 339–347

Physical, Chemical and Sensory Characteristics of Japanese-Type Plums Grown in Georgia and Alabama

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(Received 10 February 1992; revised version received 15 May 1992; accepted 9 August 1992)

Abstract: The physical, chemical and sensory characteristics of 15 plum cultivars and selections grown at Byron, GA and Clanton, AL in 1989 and 1990 were investigated. Selection BY68-1262 produced significantly larger fruit than the other plum cultivars and selections evaluated followed by 'AU-Rubrum' and 'Rubysweet'. 'Methley' fruit was the smallest. Hue angle (θ) values ranged from 105° for 'Byrongold', a yellow-skin cultivar, to 6° for BY68-1262, a deep-purple skin selection. Average firmness of the maturity 2 plums was 25 N. Mean chemical compositions for all cultivars were as follows: soluble solids—127g kg^{-1}; acidity—174·4 g kg^{-1}; soluble solids to acidity ratio—7·4, and total sugar content—96 g kg^{-1}. Hedonic scores and 'just right' percentages showed that panelists preferred 'Rubysweet' and 'Segundo' plums harvested in 1989 and BY7407–6, 'AU-Amber' and BY68-98 plums harvested in 1990. 'AU-Producer' had the lowest hedonic score. 'Robusto' and 'AU-Rosa' had the highest mean peel bitterness rating.

Key words: plums, physical, chemical, sensory characteristics.

INTRODUCTION

Plums are a crop with much potential for the fruit grower in Southeastern USA. The plums most commonly found in supermarkets are the Japanese type, and the majority are produced in California. The Japanese plums are very susceptible to disease when grown in the Southeastern USA (Norton *et al* 1989a), and most Japanese-American hybrids that survive have had low quality (Norton *et al* 1987). The plum industry is very small in the Southeastern USA, limited primarily to pick-your-own and roadside sale customers, although some of the newly developed cultivars may be shipped to distant markets.

Since 1973, new cultivars of plums have been developed that have the potential to produce high-quality fruit in the Southeastern USA. Plum breeding programs at the USDA, ARS, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA and at the Department of Horticulture, Alabama Agricultural Experiment Station, Auburn University, AL are developing cultivars with the tree health of native plums and the quality of the best California plums.

The plum breeding program at the USDA Byron Laboratory has released five Japanese-type plum cultivars since 1980 which have good disease resistance and are adapted to the high humidity of the area (Okie *et al* 1991). The USDA Byron program is currently testing a number of advanced plum selections across the south of the USA. The plum breeding program at Auburn University has developed nine plum cultivars with several promising selections currently being evaluated for possible release (Norton 1978; Norton *et al* 1984, 1987, 1989b, c, 1991).

The newest cultivars from these programs provide the plum industry with vigorous disease-resistant cultivars that produce excellent quality fruit and that offer the possibility of a competitive commercial distribution industry for the first time in the south of the USA.

Little is known abut the quality characteristics of these new plum cultivars. Optimum picking time, storage times and temperatures and distribution conditions are not known. Robertson *et al* (1991) reported on the effects of cold storage and maturity on the physical, chemical and sensory characteristics of 'AU-Rubrum' plums. They concluded that 'AU-Rubrum' plums could be stored for at least 5 weeks at 0°C without loss of quality and that the cultivar has potential for distribution to distant markets. Scientists from the same laboratory have submitted a paper for publication on the effect of maturity and ripening on the quality and sensory attributes of 'Byrongold' and 'Rubysweet' plums (Meredith *et al* 1991). The objective of this study was to investigate the physical, chemical and sensory characteristics of 14 plum cultivars and selections developed by the USDA and the Auburn University plum breeding programs.

MATERIALS AND METHODS

Samples

Plums were harvested in May and June 1989 and 1990. Cultivars 'AU-Amber', 'AU-Rubrum', 'Byrongold', 'Methley', 'Robusto', 'Rubysweet', 'Segundo' and selections BY68-98, BY68-1262, BY7407-6 and BY7788-147 were harvested at the USDA, Byron Laboratory. Cultivars 'AU-Producer', 'AU-Rosa', 'AU-Rubrum' and selections Auburn A-1 and Methley F1-1 were harvested at Chilton Area Horticulture Substation, Auburn University, Clanton, AL. Only 'AU-Rubrum' was harvested from both locations. 'Methley' was the only cultivar not bred at Auburn or Byron. The fruit were hand-picked and transported under refrigeration (−1 to +2°C) to the USDA, ARS, Russell Research Center, Athens, GA, allowed to equilibrate to room temperature and sorted by visual color and feel into one to three maturity grades depending upon the availability of fruit. In general, the surface color of maturity 1 (immature) was mostly green for 'Byrongold', a yellow-fleshed cultivar, to half red and remainder green for 'AU-Rubrum'. Maturity 2 (commercial distribution ripe) was mostly red, deep-red or purple with a trace of green to a mottled red–green mixture and a streak of color on the suture. Maturity 3 (tree ripe) was deep-red, purple or bright yellow and slightly soft to feel. Because of the long distance of the orchards from the Russell Research Center, only one harvest was made for each cultivar. The authors attempted to harvest when the majority of the fruit of a cultivar were maturity 2. Therefore, in some cases there was not enough maturity 1 or maturity 3 fruit for testing.

Physical and chemical analyses were conducted on all maturity 2 plums as harvested and on selected maturity 1 and 2 plums after artificial ripening. Sensory evaluations were conducted on artificial ripened maturity 2 plums. Fruit were ripened at 20°C and 85–90% RH for 2–8 days to a firmness of 13 N or less. The length of time the plums were ripened depended on the firmness of the fruit samples which was variable. For example, within the same lot of ripened fruit, 90% of the fruit might have a firmness of 13 N or less, but the remaining plums would either be mushy or would have a firmness greater than 13 N.

Physical measurements

Fifteen plums of each maturity grade were measured for weight, skin color and firmness before and after ripening. Fruit size of unripened fruit was determined by measuring the diameter of each fruit midway between the stem and blossom end. Ground color was measured on the greenest area of each fruit using a tristimulus colorimeter (Minolta CR-100 Chroma Meter equipped with a Minolta DP-100 data processor) and employing d/o geometry illuminating system and an 8 mm viewing aperture. L (lightness), a (green to red) and b (blue to yellow) values were measured. Minolta a and b values were used to compute value for hue angle ($\theta = \tan^{-1} b/a$), a parameter that has been shown effective for predicting visual color appearance (Little 1975).

Firmness was determined on opposite pared cheeks of 15 plums of each cultivar using a Magness-Taylor pressure tester with an 8-mm tip. The mean of the two measurements was expressed in newtons.

Chemical analyses

Fifteen to 21 plums from each maturity grade were divided into three replications of 5–7 fruit each. The fruit samples were pitted, sliced, and the slices were puréed in a Waring blender. Soluble solids (SS) were determined with a Bausch & Lomb Abbe-56 refractometer on an aliquot of the purée which was filtered through Miracloth. Titratable acidity (A), as malic acid, was de-

TABLE 1
Physical characteristics of plum cultivars grown at Byron, GA and Clanton, AL in 1989 and 1990

Cultivar[a]	*Size* (*mm*)	*Weight* (*g*)	*Firmness* (*N*)	*Skin color values*				*Year*	*Location*
				L	*a*	*b*	*θ*		
BY7788-147	45·3	53·6	18	43·0	13·8	13·0	44	1989	Byron, GA
Segundo	43·8	47·4	17	46·7	6·6	13·3	62	1989	Byron, GA
Rubysweet	52·4	72·4	24	47·8	6·8	15·3	66	1989	Byron, GA
Methley F1-1	48·1	63·9	27	32·6	15·3	6·2	22	1989	Clanton, AL
Auburn A-1	48·0	64·1	23	38·7	13·0	11·3	41	1989	Clanton, AL
AU-Producer	37·2	32·6	25	45·2	6·7	17·9	63	1989	Clanton, AL
AU-Rubrum	52·6	78·9	28	36·1	16·5	9·7	31	1989	Clanton, AL
BY7407-6	45·8	47·4	40	50·9	3·3	15·7	78	1990	Byron, GA
BY68-98	41·4	39·5	26	49·8	7·7	18·2	66	1990	Byron, GA
BY68-1262	56·7	105·2	24	32·3	9·0	1·4	6	1990	Byron, GA
Byrongold	43·1	48·7	33	58·6	−7·9	29·3	105	1990	Byron, GA
Methley	32·1	19·3	10	48·9	3·6	17·6	77	1990	Byron, GA
Robusto	38·0	30·8	10	46·1	8·5	11·5	54	1990	Byron, GA
AU-Amber	36·6	27·1	13	41·5	13·4	7·6	29	1990	Byron, GA
AU-Rubrum	41·6	39·8	43	42·4	13·6	10·0	37	1990	Byron, GA
Au-Rosa	47·8	62·1	39	41·8	16·4	16·3	39	1990	Clanton, AL
Mean	44·4	52·1	25	43·9	9·1	13·4	51		
SEM[b]	1·8[c]	6·1[c]	3[c]	2·4[c]	1·7[c]	1·7[c]	6[c]		

[a] All cultivars were maturity grade 2.
[b] Standard error of the mean.
[c] Error degree of freedom is 15.

termined by titration to pH 8·1 with 0·1 N NaOH on a solution of 5 g purée diluted with about 50 ml distilled water with a Schott Gerate automatic titrator. Total sugars and organic acids were determined by HPLC as described by Meredith *et al* (1988) and Meredith *et al* (1991), respectively. Duplicate analyses were conducted for all the chemical determinations.

Total phenolics

Intact fruit were stored at −10°C until analyzed. Peel was removed from the equatorial region of five fruit to provide a composite sample. Mesocarp was removed from the peel with scraping after which the excess moisture was removed with blotting. Approximately 0·25 mg of peel was placed in a glass tissue grinder with 10 ml of methanol/water (70:30 v) and ground to a small particle size. Mesocarp samples were removed from the same areas with a 1 cm cork borer. The pit area was removed from the plug and samples from the five fruit were composited and macerated. Samples (3·5 mg) were ground in 10 ml solvent as described above. The mixtures were then placed in a sonic bath for 5 min for extraction of the phenolic compounds (Senter *et al* 1989) after which the particulates were removed with centrifugation. Dilutions (1+9) of the extracts were made from which 1 ml was removed for analysis. Total phenols were determined with Folin–Ciocalteau reagent (Fisher Chemical Co.) by the micro-procedure of Goldstein and Swain (1963).

Sensory evaluation

After ripening for 2–5 days depending on the cultivar, maturity 2 plums were evaluated in duplicate for sensory characteristics by 10 panelists. Most panel members had some training on sensory evaluation of fruit. Unfortunately, for most of the cultivars, there was not enough fruit available to use more panel members. About 10 fruit of each sample were washed and sliced and two halves of fruit were placed into coded cups on trays. Evaluations were conducted in a panel room equipped with individual stations and white incandescent lighting. Panel members were asked first to evaluate the flesh for sweetness, sourness, texture and juiciness. The peel, with as little flesh as possible, was evaluated for bitterness. Overall hedonic like–dislike scores were given by the panelists for each sample. The sensory score sheet incorporated modified 'just right' scales (Meilgaard *et al* 1987) for sweetness, sourness, texture and juiciness. Each scale was divided into five categories with category number 3 representing the panelist's judgment of just right. Peel bitterness was evaluated using a 5-point intensity scale of: 1—not bitter, 2—slightly bitter, 3—moderately bitter, 4—very bitter, and 5—extremely bitter. The overall like–dislike for the plums were scored using the 9-point hedonic scale, with 1—dislike ex-

TABLE 2
Chemical characteristics of plum cultivars grown at Byron, GA and Clanton, AL in 1989 and 1990

Cultivar[a]	*Soluble solids* ($g\ kg^{-1}$)	*Acidity* (g *malic* kg^{-1})	*SS/A*	*Total sugars* ($g\ kg^{-1}$)	*Year*	*Location*
BY7788-147	103	18·2	5·7	85·7	1989	Byron, GA
Segundo	141	19·6	7·2	116·3	1989	Byron, GA
Rubysweet	121	14·4	8·4	87·2	1989	Byron, GA
Methley F1-1	121	16·1	7·5	102·2	1989	Clanton, AL
Auburn A-1	110	16·2	6·8	89·2	1989	Clanton, AL
AU-Producer	126	23·5	5·4	92·5	1989	Clanton, AL
AU-Rubrum	121	16·8	7·2	103·8	1989	Clanton, AL
BY7407-6	143	15·9	9·0	109·4	1990	Byron, GA
BY68-98	134	17·7	7·6	93·7	1990	Byron, GA
BY68-1262	120	12·6	9·5	91·5	1990	Byron, GA
Byrongold	118	16·3	7·2	91·1	1990	Byron, GA
Methley	116	14·9	7·8	77·8	1990	Byron, GA
Robusto	141	18·4	7·7	95·2	1990	Byron, GA
AU-Amber	155	17·1	9·1	116·1	1990	Byron, GA
AU-Rubrum	132	18·9	7·0	96·4	1990	Byron, GA
AU-Rosa	127	21·5	5·9	89·7	1990	Clanton, AL
Mean	127	17·4	7·4	96·1		
SEM[b]	8[c]	1·6[c]	0·7[c]	6·2[c]		

[a] All cultivars were maturity grade 2.
[b] Standard error of the mean.
[c] Error degree of freedom is 3.

TABLE 3
Effect of maturity on physical and chemical characteristics of plum cultivars[a]

Maturity	*Number of cultivars*	*Firmness* (N)	*Skin color values*				*Soluble solids* ($g\ kg^{-1}$)	*Acidity* (g *malic* kg^{-1})	*SS/A*	*Total sugars* ($g\ kg^{-1}$)
			L	a	b	θ				
1	10	32	50·8	1·5	19·5	82	118	17·9	6·6	88·8
2	10	23	41·5	12·8	10·9	41	131	17·6	7·4	100·4
3	5	14	37·8	12·2	6·2	25	138	16·2	8·5	103·3
Overall SEM		3[b]	1·7[b]	1·6[b]	1·7[b]	8[b]	6[c]	1·2[c]	0·6[c]	4·4[c]

[a] Data are mean of 10 cultivars for maturity 1 and 2 and of 5 cultivars for maturity 1, 2 and 3.
[b] Error degree of freedom is 15.
[c] Error degree of freedom is 3.

tremely, and 9—like extremely (Peryam and Pilgrim 1957).

Statistical analysis

The physical and chemical data were analyzed by the General Linear Models program of the Statistical Analysis System (SAS) for personal computer (SAS 1985). 'Just right' scales data were analyzed by χ^2 to compare frequency distribution of the panelists responses to the fruit. For statistical analyses, response categories 1 and 2 were combined and response categories 4 and 5 were combined. This reduced the number of response categories for analysis to three as required by the Proc Frequency procedure. Hedonic scores and bitterness were subjected to analysis of variance.

RESULTS AND DISCUSSION

The physical and chemical characteristics of plum cultivars grown at Byron, GA and Clanton, AL are shown in Tables 1 and 2. Selection BY68-1262 produced significantly larger fruit than the other plum cultivars and selections evaluated followed by AU-Rubrum and

TABLE 4
Effects of ripening on physical and chemical characteristics of selected plum cultivars[a,b]

Cultivar	*Maturity*	*Ripened (days)*	*Firmness (N)*	*L*	*a*	*b*	*θ*
Segundo	1	0	28*	55·7*	−8·6*	20·3*	113*
	1	3	3**	39·7**	15·8**	7·8**	26**
	2	0	17*	46·7*	6·6*	13·3*	47*
	2	3	4**	30·9**	9·4**	1·8**	20*
Rubysweet	1	0	30*	48·6*	4·4*	16·1*	75*
	1	3	3**	42·6**	10·9**	12·4**	49**
	2	0	24*	47·8*	6·8*	15·3*	17*
	2	2	7**	42·9**	11·8**	13·2**	18*
AU-Rubrum	1	0	31*	46·3*	4·3*	18·0*	75*
	1	8	19**	34·4**	16·0**	5·1**	17**
	2	0	28*	36·1*	16·5*	9·7*	31*
	2	7	3**	29·9**	12·5**	1·9**	8**
Robusto	1	0	22*	56·2*	−6·9*	24·2*	105*
	1	3	—	37·1**	18·7**	6·6**	19**
	2	0	10*	46·1*	8·5*	11·5*	54*
	2	2	5**	37·7**	16·0**	5·3**	20**
AU-Amber	1	0	21*	54·5*	0·2*	20·4*	86*
	1	4	6**	34·7**	14·2**	5·0**	19**
	2	0	13*	41·5*	13·4*	7·6*	29*
	2	3	5**	33·1**	8·7**	0·1**	1**
AU-Rosa	1	0	45*	58·9*	−8·5*	31·5*	105*
	1	3	9**	41·3**	18·0**	12·9**	35**
	2	0	39*	41·8*	16·4*	16·3*	45*
	2	2	8**	35·6**	17·1*	7·7**	23**

[a] Selected cultivars in which adequate quantities of maturity 1 and maturity 2 fruit were available for ripening at 20°C.
[b] Compared cultivars of unripened and ripened fruit of same maturity; values with same number of asterisks were non-significant.

TABLE 5
Phenolic and organic acid contents of ripened plums grown at Byron, GA and Clanton, AL in 1990

Cultivar	*Maturity*	*Ripened (days)*[a]	*Phenolics (μg mg⁻¹ tissue)*			*Acids (g kg⁻¹ whole fruit)*				
			Peel	*Mesocarp*	*Total*	*Quinic*	*Malic*	*Citric*	*Succinic*	*Total*
BY7407-6	2	4	10·77	1·41	12·18	2·2	11·1	0·2	Trace	13·5
BY68-98	2	2	11·43	1·46	12·89	3·7	11·7	0·2	Trace	15·6
BY68-1262	2	3	16·50	1·24	17·74	2·3	12·7	0·1	Trace	15·1
Byrongold	2	3	8·57	1·41	9·98	2·4	12·0	0·2	Trace	14·6
Methley	2	2	12·78	1·39	14·17	5·2	7·6	0·2	Trace	13·0
Robusto	1	3	14·17	2·33	16·50	3·4	11·9	0·2	Trace	15·5
Robusto	2	2	21·88	3·07	24·95	4·2	11·7	0·2	Trace	16·1
AU-Rosa	1	3	5·19	0·75	5·94	1·6	17·5	0·1	—	19·2
AU-Rosa	2	2	6·04	0·86	6·90	1·9	18·3	0·2	—	20·4
AU-Amber	1	4	18·46	2·47	20·93	3·6	10·9	0·2	Trace	14·7
AU-Amber	2	3	25·45	2·93	28·38	4·8	11·0	0·2	Trace	16·0
AU-Amber	3	0	30·00	1·95	31·05	3·3	10·5	0·3	Trace	14·1
AU-Rubrum	1	5	20·50	1·65	22·15	4·0	14·7	0·2	Trace	18·9
AU-Rubrum	2	4	29·12	1·54	30·66	3·2	12·9	0·2	Trace	16·3
AU-Rubrum	3	0	28·65	1·77	30·42	3·8	15·9	0·2	Trace	19·9

[a] Plums ripened at 20°C and 85–90% RH.

TABLE 6

Frequency distribution[a] (%) of responses to quality sensory attributes, and hedonic scores of ripened plums grown at Byron, GA and Clanton, AL in 1989[b]

	BY7788-147	*Segundo*	*Rubysweet*	*Methley*	*Auburn*	*AU-Producer*	*AU-Rubrum*	*Mean*	*SEM*[c]
Sweetness									
Too sweet	0	5	0	0	0	0	5		
Somewhat too sweet	15	5	22	10	20	0	10		
Just about right	50	65	76	55	35	20	40		
Somewhat not sweet	25	15	2	10	40	45	45		
Not sweet	10	10	0	25	5	35	0		
Sourness									
Too sour	0	5	0	10	0	50	0		
Somewhat too sour	0	5	2	25	10	30	25		
Just about right	55	65	70	40	45	15	40		
Somewhat not sour	25	15	22	20	35	5	20		
Not sour	20	10	6	5	10	0	15		
Texture (firmness)									
Too firm	0	0	0	15	0	20	0		
Somewhat too firm	10	10	0	10	10	45	20		
Just about right	15	50	32	40	55	30	55		
Somewhat too soft	55	25	52	30	15	5	10		
Too soft	20	15	16	5	20	0	15		
Juiciness									
Too dry	0	0	0	0	0	15	5		
Somewhat too dry	20	20	0	20	20	35	5		
Just about right	70	65	60	65	65	45	70		
Somewhat too juicy	10	10	32	10	10	5	10		
Too juicy	0	5	8	5	5	0	10		
Hedonic score	5·2	5·8	6·6	5·4	5·3	3·2	5·5	5·3	0·2
Bitterness (peel)	2·4	3·1	2·2	2·8	2·3	3·1	2·3	2·6	0·1

[a] Values under each category for sweetness, sourness, texture and juiciness represent percentages of total responses ($n = 20$).
[b] All cultivars were maturity grade 2 and were ripened at 20°C and 85–90% RH.
[c] Standard error of the mean.

'Rubysweet' (Table 1). 'Methley', the oldest cultivar, was the smallest in size and weight and was also one of the softest. The size and weight of 'AU-Producer' were lower than normal probably because of inadequate pruning and thinning. As would be expected, the color of the different cultivars was variable. Hue angle (θ) ranged from 105° for Byrongold, a yellow-skin cultivar, to 6° for BY68-1262, a deep-purple skin selection. Byrongold also had the highest L and b values which would be expected for a yellow-skin cultivar. BY68-1262 had the lowest L and b values. Low L and b values would be expected more for maturity 3 than for maturity 2 plums; however, the firmness of BY68-1262 shows that it belongs to maturity 2 grade. Cultivars vary in the rapidity in which blush color completely covers the plum. The average firmness of the maturity 2 plums (equivalent to commercial distribution-ripe) was 25 N. This compares with a firmness of 45–50 N for distribution-ripe peaches. However, the shelf-life of plums at room temperature appears to be significantly longer than that of peaches. The physical characteristics of plums grown in 1989 and 1990 were not significantly different.

'AU-Amber', BY7407-6, 'Robusto' and 'Segundo' (all grown at Byron, GA) had the highest SS contents, and 'Segundo', 'AU-Amber' and BY7407-6 had highest total sugar contents, respectively (Table 2). The SS contents of the fruit in this study were significantly lower than the SS contents reported by Norton *et al* (1991). They reported values of 176, 182, 165, 185 and 167 g kg^{-1} for 'AU-Rosa', 'AU-Amber', 'AU-Producer', 'Methley' and 'Santa Rosa', respectively. Vangdal (1985) reported that the threshold value of SS for acceptable quality was 125 g kg^{-1} for plums.

The titratable acidity of the cultivars averaged 17·4 g kg^{-1}, ranging from 12·6 to 23·5 g kg^{-1} (Table 2). 'AU-Producer' had the highest acidity which is reflected in its low sensory hedonic score (see Table 6). The titratable acidity of plums is two to three times greater than the acidity of peaches (Robertson *et al* 1990). Vangdal (1985), in a study of European plums, concluded that the SS/A ratio in plums should be between 12 and 24. In the present study, the highest ratio obtained was 12 for 'AU-Amber', maturity grade 3, and all the other cultivars had ratios lower than 10.

TABLE 7

Frequency distribution[a] (%) of responses to quality sensory attributes, bitterness scores and hedonic scores of ripened plum cultivars grown at Byron, GA and Clanton, AL in 1990[b]

	BY7407-6	*BY68-98*	*BY68-1262*	*Byrongold*	*Methley*	*Robusto*	*AU-Amber*	*AU-Rubrum*	*AU-Rosa*	*Mean*	*SEM*[c]
Sweetness											
Too sweet	15	0	5	15	0	0	25	0	5		
Somewhat too sweet	10	20	5	20	10	15	25	0	0		
Just about right	65	45	15	30	45	25	40	40	40		
Somewhat not sweet	10	20	55	30	35	45	10	40	35		
Not sweet	0	15	20	5	10	15	0	20	20		
Sourness											
Too sour	0	0	15	0	0	5	0	0	25		
Somewhat too sour	0	5	15	5	5	5	5	30	25		
Just about right	60	55	50	45	55	60	40	60	45		
Somewhat not sour	30	35	10	25	40	30	45	10	5		
Not sour	10	5	10	25	0	0	10	0	0		
Texture (firmness)											
Too firm	0	0	10	0	0	0	0	10	15		
Somewhat too firm	10	5	45	5	5	0	0	30	20		
Just about right	55	75	35	15	90	45	20	50	60		
Somewhat too soft	20	15	5	40	5	40	50	10	5		
Too soft	15	5	5	40	0	15	30	0	0		
Juiciness											
Too dry	0	0	10	0	5	0	0	5	5		
Somewhat too dry	0	30	20	5	20	10	0	35	30		
Just about right	90	65	65	55	75	50	60	55	65		
Somewhat too juicy	5	5	5	30	0	25	20	5	0		
Too juicy	5	0	0	10	0	15	20	0	0		
Hedonic score	6·5	6·0	5·2	4·0	5·4	3·9	6·1	5·5	4·6	5·3	0·2
Bitterness (peel)	2·6	2·4	3·1	2·9	3·0	3·6	2·9	2·9	3·5	3·0	0·1

[a] Values under each category for sweetness, sourness, texture and juiciness represent percentages of total responses ($n = 20$).
[b] All cultivars were maturity grade 2 and were ripened at 20°C and 65–90% RH.
[c] Standard error of the mean.

Although the cultivars evaluated were different, neither planting location nor year of harvest appeared to have a significant effect on the physical and chemical characteristics of the fruit. The SS contents tended to be higher in 1990, a dry year, but a comparison of the mean total sugar contents of the two years show they were not significantly different.

The effects of maturity on the physical and chemical characteristics of selected plum cultivars are shown in Table 3. Firmness, L values, b values, θ and acidity decreased significantly, and SS, SS/A ratio and total sugars increased significantly with increasing maturity. Maturity 2 a values were significantly higher than maturity 1 values, but there were no significant differences between maturity 2 and 3 a values. As plums ripen, there is a striking change in color from mostly green for maturity 1 (immature fruit) to deep-yellow, red and purple colors (smaller L and b values) depending on cultivar for maturity 3.

The effects of artificial ripening on physical and chemical characteristics of selected plum cultivars are shown in Table 4. The fruit were artificially ripened at a temperature of 20°C to a firmness of about 5 N on average. In general, a firmness of 13 N or less would be considered eating ripe for plums. Below 5 N, the texture would be too soft for most consumers. A range of 3–8 days was required to attain a firmness of less than 13 N for maturity 1 fruit and 2–7 days for maturity 2 fruit. 'AU-Rubrum' had the longest shelf-life of all the cultivars requiring 7–8 days to soften the fruit. In general, ripening of fruit resulted in a significant decrease in L values, b values and θ for both maturity 1 and 2 fruit. For maturity 1 fruit a values increased but were variable for maturity 2 fruit. Ripening had no significant effect on SS, total sugars and acidity levels. Meredith *et al* (1991) studied the effect of artificially ripening on the quality of 'Byrongold' and 'Rubysweet' cultivars. They reported that ripening for 3 days had no significant effect on the total concentration of organic acids, but when fruit were ripened for 6 days, total acids decreased. However, the fruit were probably not at optimum firmness for eating. Robertson *et al* (1991) reported that

the titratable acidity of 'AU-Rubrum' plums slightly decreased when artificially ripened.

The major non-volatile acids found in some ripened plum cultivars were malic, quinic and citric with only a trace of succinic acid (Table 5). The quantities of non-volatile acids in the plum mesocarp were about twice the concentration found in peaches (Chapman and Horvat 1989, 1990). The ratio of malic to citric or quinic acids was also much higher in plums than in peaches.

The peel of plums is very bitter to the taste. So it is not surprising that it contains a high concentration of phenolics (Noble 1990). In fact the total phenolic content of plum peel is about ten times that of the plum mesocarp (Table 5). Plum mesocarp also contains substantially more total phenolics than peach mesocarp (Robertson *et al* 1988; Chapman and Horvat 1989; Meredith *et al* 1989).

Percent frequency distribution of response to sensory attributes, mean bitterness (peel) ratings and hedonic scores of plum cultivars grown at Byron, GA and Clanton, AL in 1989 and 1990 are shown in Tables 6 and 7. Hedonic scores showed that panelists preferred 'Rubysweet' and 'Segundo' plums in 1989 and BY7407-6, 'AU-Amber' and BY68-98 plums in 1990. 'Rubysweet' had the highest 'Just right' percent for sweetness (76% 'just about right') and sourness (70% 'just about right') and the lowest bitterness score (2·2) of all cultivars. 'AU-Producer' had a 50% response of 'too sour' and 45% response of 'somewhat not sweet'; and as a result had the lowest hedonic score (3·2). 'Robusto' and 'AU-Rosa' had the highest mean peel bitterness rating which probably explains the low hedonic score of 'Robusto' since the flavor of the peel was considered by the panel in the like–dislike hedonic ratings. In general, there appears to be no relationship between plum skin color, SS, acidity and total sugar contents with sensory evaluations. However, three cultivars with the highest hedonic scores ('Rubysweet', BY7407-6 and 'AU-Amber') also had the higher SS/A ratio.

Because fruit of all cultivars could not be obtained from both locations in both years, conclusions can not be drawn concerning effects of planting location and year on quality attributes. Cultivars such as 'Rubysweet', 'Byrongold', 'AU-Rubrum' and 'AU-Rosa' have excellent size, firmness and quality and would be excellent for fresh markets and for commercial production in the Southeastern USA. Cultivars such as 'Segundo', 'Robusto', 'AU-Amber' and 'Methley' would be more adapted for home, roadside and local markets because of their small size and medium firmness.

ACKNOWLEDGMENTS

The authors thank Ms Brenda Lyon for advice in conducting the sensory evaluation studies, Ruel L Wilson for technical assistance in the statistical analysis, and Judy Davis and Don Howell for technical assistance.

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